NASA-TM-83059 19830016603

# Stress Intensity and Displacement Coefficients for Radially Cracked Ring Segments Subject to Threepoint Bending

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March 1983

**NASA**

NF00359

# STRESS INTENSITY AND DISPLACEMENT COEFFICIENTS FOR RADIALLY CRACKED RING SEGMENTS SUBJECTED TO THREE POINT RADIAL LOADING

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## SUMMARY

The boundary collocation method was used to generate Mode I stress intensity and crack mouth displacement coefficients for internally and externally radially cracked ring segments (arc bend specimens) subjected to three point radial loading. Numerical results were obtained for ring segment outer-to-inner radius ratios $(R_0/R_i)$ ranging from 1.10 to 2.50 and crack length-to-width ratios (a/W) ranging from 0.1 to 0.8. Stress intensity and crack mouth displacement coefficients were found to depend on the ratios $R_0/R_i$ and a/W as well as the included angle between the directions of the reaction forces.

## NOMENCLATURE

| | |
|---|---|
| a | crack length |
| B | specimen thickness |
| E | Young's modulus |
| E' | $= E/(1 - v^2)$ for plane strain, $E' = E$ for plane stress |
| K | Mode I stress intensity factor |
| M | crack plane moment at nominal neutral axis position |
| | $M = P \tan \theta \, (R_i + R_0 + a)/4$ for internally cracked segments |
| | $M = P \tan \theta \, (R_i + R_0 - a)/4$ for externally cracked segments |
| P | applied load (Fig. 1) |
| $R_i$ | ring segment inner radius |
| $R_0$ | ring segment outer radius |
| V | total crack mouth displacement |
| W | ring segment width $(R_0 - R_i)$ |
| R,$\theta$ | polar coordinate system |
| $\theta_1$ | angle defining ring segment half span (Fig. 1) |
| $\theta_z$ | angle defining ring segment boundary BC |

N83-24874

v          Poisson's ratio

$\chi(R,\theta)$     Stress function


## INTRODUCTION

There are many applications for tubular product forms, in particular high performance rolling element bearing races such as are used in jet engines, for which measurement of the plane strain fracture toughness, Kic, is highly important in the assessment of reliable endurance. It is often convenient and economical to test arc-shaped specimens machined from rings cut from bearing races or cylindrical blanks for this purpose. While there is a U.S. standard test method for testing arc-shaped specimens by loading them by means of pins inserted through holes bored through the wall thickness, this is impracticable for thin-walled tubes or rings because the greatest loading pin diameter that could be used would be to small to transmit the necessary load. For such thin-walled specimens an alternative test procedure of loading the arc-shaped specimens in three-point bending is appropriate and satisfactory, given only that an accurate fracture mechanics analysis is available. The purpose of this report is to provide the necessary results of fracture mechanics analysis in the form of stress intensity and crack mouth displacement coefficients for a sufficiently wide variety of combinations of the significant geometrical variables: ratio of outer to inner radius, $R_0/R_i$; ratio of crack depth to wall thickness, $a/W = a/(R_0 - R_i)$; and the included angle subtended by the support points at the center of curvature. The data is given here in tabular form for ready reference and convenience of interpolation.


## METHOD

The analytical solution was obtained by the boundary collocation method (1) with the ring segment modelled as shown in Figure 1. The stress function boundary conditions along boundary BC, defined by the angle $\theta_z$ less than $\theta_1$, were obtained from the known stress function solution to the bending of a curved bar by radial forces (2). From the boundary requirements along AB and CD, that the normal and shear stresses be zero, we obtained the stress function and its normal derivative compatible with that along boundary BC (see appendix).


## RESULTS AND DISCUSSION

The primary results are given in tables 1 to 10 in the form of dimensionless stress intensity coefficients $KBW^{1/2}/P$, $KBW^{1/2}/P \tan \theta$ and $KBW^{3/2}/M$; and the crack mouth displacement coefficient $EBVW/6M$. Each table covers one value of $R_0/R_i$: 1.1, 1.25, 1.5, 2.0, or 2.5; tables 1 through 5 for internally cracked specimens, and 6 through 10 for external cracks. The major variable in each table is a/W, from 0.1 to 0.8 at intervals of 0.1. For each value of a/W results are given for values of the angle $\theta$, at intervals of $9°$ from $90°$ down to $36°$ or less.

It is notable that the coefficient $KBW^{1/2}/P$ is a strong function of $\theta_1$, but the dependence of $KBW^{1/2}/P \tan \theta_1$ is much weaker, as is that of the other coefficients. The reason for this is that the bending moment is

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proportional to $P \tan \theta_1$. Nevertheless, this weaker dependence of the coefficients on $\theta_1$ is by no means negligible, and needs to be taken into consideration in the design of an efficient testing arrangement.

The coefficints given in Tables 1 through 10 are not well suited for direct interpolation since they all increase rapidly and indefinitely as a/W approaches unity. The following coefficient forms are much more suitable for least squares fitting: $KB(W - a)^{3/2}/PW \tan \theta_1$; $KB(W - a)^{3/2}/M(a/W)^{1/2}$; and $EBVW(W - a)^2/M(W + a)^2$. An example is given in Table 11 where values of $KB(W - a)^{3/2}/M(a/W)^{1/2}$ for internally and externally cracked curved bars with $R_0/R_i = 1.1$ and 2.5 are compared with those for a straight bar (reference 3). The results for the straight bar include the limit cases for a/W = 0 and 1.0, obtained by asymptotic analysis, and illustrate very clearly the advantages of this particular form of stress intensity coefficient for interpolation purposes.

Table 11 also serves to show the trend of the stress intensity coefficient with specimen curvature. In dimensionless terms the curvature can be defined as the ratio of specimen depth, $R_0 - R_i$, to the radius of curvature of the cracked surface, $R_i$ for the inner surface, and $-R_0$ for the outer surface. The general trend is for the stress intensity coefficient to decrease as the curvature decreases, as illustrated particularly by the results for a/W = 0.1. For the other values of a/W there is an anomaly in this trend insofaras the stress intensity coefficient for zero curvature (straight bar) is slightly lower than both that for slightly positive curvature, 0.1, and for slightly negative curvature, -0.091. There is no apparent mechanical explanation for this anomaly, and it seems most likely to be due to the (unavoidably) different boundary conditions used in the collacation analysis for the curved bars compared with those for the straight bar.

Apart from this anomaly, the effect of curvature diminishes with increasing relative crack depth from a factor of 1.88 over the range of curvature considered for a/W = 0.1, to a factor of 1.16 for a/W = 0.8. At all crack lengths the effect is stronger for external than for internal cracks.

## APPENDIX

The results presented herein were obtained by plane elasto-static boundary collocation analysis of a homogeneous isotropic body. The analytical technique is described in detail by Gross and Mendelson (1) and Gross and Srawley (4). The boundary conditions to be satisfied by the stress function and its normal derivative were obtained from the known solution to a curved bar subjected to an end radial load (2). For a ring-segment containing an internal radial crack as shown in figure 1, we have the following stress function boundary conditions:

along arc AB

$$X(R_i, \theta) = 0$$

$$\left. \frac{\partial X}{\partial n} \right|_{R_i, \theta} = 0$$

along line BC

$$x(R, \theta_z) = \frac{-P \sin(\theta_1 - \theta_z)}{((R_i^2 - R_o^2) + (R_i^2 + R_o^2) \ln(R_o/R_i)) \, 2 \cos \theta_1}$$

$$\times \left[ \frac{R^3}{2} - \frac{R_i^2 R_o^2}{2R} - R \left( (R_i^2 + R_o^2) \ln \frac{R}{R_i} + \left( \frac{R_i^2 - R_o^2}{2} \right) \right) \right]$$

$$\left. \frac{\partial x}{\partial n} \right|_{R, \theta_z} = \frac{P \cos(\theta_1 - \theta_z)}{\left( (R_i^2 - R_o^2) + (R_i^2 + R_o^2) \ln\left( \frac{R_o}{R_i} \right) \right) 2 \cos \theta_1}$$

$$\times \left[ \frac{R^2}{2} - \frac{R_i^2 R_o^2}{2R^2} - (R_i^2 + R_o^2) \ln \frac{R}{R_i} - \left( \frac{R_i^2 - R_o^2}{2} \right) \right]$$

along arc CD

$$x(R_o, \theta) = PR_o \frac{\sin(\theta_1 - \theta_z)}{2 \cos \theta_1}$$

$$\left. \frac{\partial x}{\partial n} \right|_{R_o, \theta} = \frac{P \sin(\theta_1 - \theta)}{2 \cos \theta_1}$$

For a ring segment containing an external radial crack as shown in figure 1, we have the following stress function boundary conditions:

along arc AB

$$x(R_o, \theta) = 0$$

$$\left. \frac{\partial x}{\partial n} \right|_{R_o, \theta} = 0$$

along BC

$$x(R, \theta_z) = \frac{P \sin(\theta_1 - \theta_z)}{\left[ (R_i^2 - R_o^2) + (R_i^2 + R_o^2) \ln\left( \frac{R_o}{R_i} \right) \right] 2 \cos \theta_1}$$

$$\times \left[ \frac{R^3}{2} - \frac{R_i^2 R_o^2}{2R} - R \left( (R_i^2 + R_o^2) \ln \left( \frac{R}{R_o} \right) + \left( \frac{R_o^2 - R_i^2}{2} \right) \right) \right]$$

$$\left. \frac{\partial x}{\partial n} \right|_{R, \theta_z} = \frac{-P \cos(\theta_1 - \theta_z)}{\left[ (R_i^2 - R_o^2) + (R_i^2 + R_o^2) \ln \left( \frac{R_o}{R_i} \right) \right] 2 \cos \theta_1}$$

$$\times \left[ \frac{R^2}{2} - \frac{R_i^2 R_o^2}{2R^2} - (R_i^2 + R_o^2) \ln \left( \frac{R}{R_o} \right) - \left( \frac{R_o^2 - R_i^2}{2} \right) \right]$$

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along arc CD

$$x(R_i, \theta) = \frac{PR_i \sin(\theta_1 - \theta)}{2 \cos \theta_1}$$

$$\left.\frac{\partial x}{\partial n}\right|_{R_i, \theta} = \frac{-P \sin(\theta_1 - \theta)}{2 \cos \theta_1}$$

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TABLE 1 STRESS INTENSITY AND DISPLACEMENTS COEFFICIENTS FOR INTERNALLY
CRACKED RING SEGMENTS WITH RATIO OF OUTER TO INNER RADIUS = 1.10

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.10000      OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000

AVERAGE VALUES

| $\theta_1$ | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 3.75075 | 0.59821 |
| 81.00 | 124.71982 | 19.75365 | 3.74477 | 0.59773 |
| 72.00 | 60.69350 | 19.72050 | 3.73848 | 0.59721 |
| 63.00 | 38.63155 | 19.68375 | 3.73152 | 0.59664 |
| 54.00 | 27.03290 | 19.64055 | 3.72333 | 0.59597 |
| 45.00 | 19.58611 | 19.58611 | 3.71301 | 0.59512 |
| 36.00 | 14.17572 | 19.51117 | 3.69880 | 0.59395 |
| 27.00 | 9.88199 | 19.39449 | 3.67668 | 0.59214 |
| 18.00 | 6.22953 | 19.17252 | 3.63460 | 0.58869 |
| 11.46 | 3.81178 | 18.80318 | 3.56459 | 0.58294 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.20000      OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000

AVERAGE VALUES

| $\theta_1$ | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 5.15325 | 1.24076 |
| 81.00 | 172.07825 | 27.25449 | 5.14236 | 1.23869 |
| 72.00 | 83.69402 | 27.19382 | 5.13091 | 1.23652 |
| 63.00 | 53.23891 | 27.12656 | 5.11822 | 1.23411 |
| 54.00 | 37.22768 | 27.04749 | 5.10331 | 1.23129 |
| 45.00 | 26.94785 | 26.94785 | 5.08451 | 1.22772 |
| 36.00 | 19.47913 | 26.81075 | 5.05863 | 1.22281 |
| 27.00 | 13.55194 | 26.59717 | 5.01834 | 1.21517 |
| 18.00 | 8.50995 | 26.19092 | 4.94168 | 1.20062 |
| 11.46 | 5.17240 | 25.51500 | 4.81415 | 1.17643 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.30000      OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000

AVERAGE VALUES

| $\theta_1$ | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 6.69004 | 2.22800 |
| 81.00 | 224.45135 | 35.54958 | 6.67598 | 2.22377 |
| 72.00 | 109.16805 | 35.47083 | 6.66119 | 2.21932 |
| 63.00 | 69.44414 | 35.38354 | 6.64430 | 2.21439 |
| 54.00 | 48.56006 | 35.28093 | 6.62553 | 2.20859 |
| 45.00 | 35.15163 | 35.15163 | 6.60125 | 2.20129 |
| 36.00 | 25.40987 | 34.97365 | 6.56783 | 2.19124 |
| 27.00 | 17.67873 | 34.69649 | 6.51578 | 2.17558 |
| 18.00 | 11.10228 | 34.16927 | 6.41677 | 2.14580 |
| 11.46 | 6.74397 | 33.29210 | 6.25204 | 2.09626 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.40000      OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000

AVERAGE VALUES

| 1 | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 8.61745 | 3.77627 |
| 81.00 | 290.51636 | 46.01326 | 8.60062 | 3.76916 |
| 72.00 | 141.32294 | 45.91858 | 8.58292 | 3.76168 |
| 63.00 | 89.91431 | 45.81360 | 8.56330 | 3.75338 |
| 54.00 | 62.88721 | 45.69022 | 8.54024 | 3.74364 |
| 45.00 | 45.53473 | 45.53473 | 8.51117 | 3.73135 |
| 36.00 | 32.92743 | 45.32074 | 8.47117 | 3.71445 |
| 27.00 | 22.92223 | 44.98743 | 8.40887 | 3.68812 |
| 18.00 | 14.41131 | 44.35341 | 8.29036 | 3.63803 |
| 11.46 | 8.77748 | 43.29857 | 8.09320 | 3.55470 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.50000      OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000

AVERAGE VALUES

| $\theta_1$ | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 11.39689 | 6.41714 |
| 81.00 | 386.12549 | 61.15636 | 11.37793 | 6.40528 |
| 72.00 | 187.89017 | 61.04918 | 11.35800 | 6.39281 |
| 63.00 | 119.58269 | 60.93039 | 11.33590 | 6.37898 |
| 54.00 | 83.67133 | 60.79076 | 11.30992 | 6.36272 |
| 45.00 | 60.61601 | 60.61601 | 11.27718 | 6.34225 |
| 36.00 | 43.86327 | 60.37262 | 11.23212 | 6.31405 |
| 27.00 | 30.56920 | 59.95544 | 11.16195 | 6.27014 |
| 18.00 | 19.26056 | 59.27794 | 11.02846 | 6.18662 |
| 11.46 | 11.77483 | 58.08417 | 10.80637 | 6.04767 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.60000      OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000

AVERAGE VALUES

| $\theta_1$ | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 15.78401 | 11.08025 |
| 81.00 | 537.41431 | 85.11809 | 15.76262 | 11.06670 |
| 72.00 | 261.59253 | 84.99666 | 15.74013 | 11.05245 |
| 63.00 | 166.55112 | 84.86200 | 15.71519 | 11.03665 |
| 54.00 | 116.58469 | 84.70374 | 15.68588 | 11.01808 |
| 45.00 | 84.50426 | 84.50426 | 15.64895 | 10.99467 |
| 36.00 | 61.19649 | 84.22974 | 15.59811 | 10.96247 |
| 27.00 | 42.69933 | 83.80222 | 15.51393 | 10.91230 |
| 18.00 | 26.96471 | 82.95094 | 15.36532 | 10.81698 |
| 11.46 | 16.54918 | 81.63582 | 15.11775 | 10.65812 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.70000      OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000

AVERAGE VALUES

| $\theta_1$ | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 24.32671 | 22.67525 |
| 81.00 | 832.44800 | 131.84688 | 24.30353 | 22.64359 |
| 72.00 | 405.37549 | 131.71471 | 24.27917 | 22.61028 |
| 63.00 | 258.21680 | 131.56818 | 24.25217 | 22.57338 |
| 54.00 | 180.85106 | 131.39597 | 24.22043 | 22.52997 |
| 45.00 | 131.17896 | 131.17896 | 24.18044 | 22.47527 |
| 36.00 | 95.09003 | 130.88025 | 24.12537 | 22.40004 |
| 27.00 | 66.44974 | 130.41501 | 24.03763 | 22.28081 |
| 18.00 | 42.08684 | 129.53008 | 23.87650 | 22.05930 |
| 11.46 | 25.95984 | 128.05777 | 23.60509 | 21.68853 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.80000      OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000

AVERAGE VALUES

| $\theta_1$ | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 44.10413 | 55.84958 |
| 81.00 | 1516.51465 | 240.19237 | 44.07195 | 55.78879 |
| 72.00 | 738.66797 | 240.00800 | 44.03812 | 55.72431 |
| 63.00 | 470.64063 | 239.80362 | 44.00063 | 55.65362 |
| 54.00 | 329.73047 | 239.56339 | 43.95653 | 55.57059 |
| 45.00 | 239.26064 | 239.26064 | 43.90099 | 55.46555 |
| 36.00 | 173.53029 | 238.84378 | 43.82454 | 55.32103 |
| 27.00 | 121.36641 | 238.19501 | 43.70546 | 55.09589 |
| 18.00 | 76.99309 | 236.96059 | 43.47896 | 54.66765 |
| 11.46 | 47.62024 | 234.90674 | 43.10213 | 53.95517 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.10000    OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000

| $\theta_1$ | AVERAGE VALUES $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 3.80999 | 0.58643 |
| 81.00 | 54.48929 | 8.63026 | 3.79352 | 0.58489 |
| 72.00 | 26.43990 | 8.59085 | 3.77620 | 0.58327 |
| 63.00 | 16.77475 | 8.54717 | 3.75700 | 0.58147 |
| 54.00 | 11.69349 | 8.49582 | 3.73442 | 0.57936 |
| 45.00 | 8.43111 | 8.43111 | 3.70598 | 0.57670 |
| 36.00 | 6.06085 | 8.34205 | 3.66683 | 0.57303 |
| 27.00 | 4.17981 | 8.20334 | 3.60586 | 0.56733 |
| 18.00 | 2.57969 | 7.93948 | 3.48988 | 0.55647 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.20000    OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000

| $\theta_1$ | AVERAGE VALUES $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 5.33397 | 1.29359 |
| 81.00 | 77.05823 | 12.20483 | 5.30645 | 1.28843 |
| 72.00 | 37.35773 | 12.13827 | 5.27751 | 1.28301 |
| 63.00 | 23.67789 | 12.06450 | 5.24543 | 1.27700 |
| 54.00 | 16.48598 | 11.97776 | 5.20772 | 1.26993 |
| 45.00 | 11.86848 | 11.86848 | 5.16020 | 1.26103 |
| 36.00 | 8.51367 | 11.71806 | 5.09480 | 1.24878 |
| 27.00 | 5.85127 | 11.48377 | 4.99294 | 1.22970 |
| 18.00 | 3.58651 | 11.03813 | 4.79919 | 1.19340 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.30000    OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000

| $\theta_1$ | AVERAGE VALUES $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 6.85762 | 2.30433 |
| 81.00 | 100.14928 | 15.86209 | 6.82240 | 2.29474 |
| 72.00 | 48.55347 | 15.77600 | 6.78537 | 2.28465 |
| 63.00 | 30.77480 | 15.68055 | 6.74432 | 2.27347 |
| 54.00 | 21.42798 | 15.56836 | 6.69606 | 2.26033 |
| 45.00 | 15.42698 | 15.42698 | 6.63526 | 2.24377 |
| 36.00 | 11.06697 | 15.23259 | 6.55156 | 2.22098 |
| 27.00 | 7.60686 | 14.92930 | 6.42120 | 2.18547 |
| 18.00 | 4.66351 | 14.35281 | 6.17325 | 2.11794 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.40000    OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000

| $\theta_1$ | AVERAGE VALUES $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 8.78090 | 3.89351 |
| 81.00 | 129.68169 | 20.53954 | 8.74024 | 3.87347 |
| 72.00 | 62.90503 | 20.43906 | 8.69749 | 3.85240 |
| 63.00 | 39.89539 | 20.32770 | 8.65010 | 3.82904 |
| 54.00 | 27.79851 | 20.19681 | 8.59439 | 3.80158 |
| 45.00 | 20.03183 | 20.03183 | 8.52419 | 3.76697 |
| 36.00 | 14.38903 | 19.80478 | 8.42757 | 3.71935 |
| 27.00 | 9.91086 | 19.45113 | 8.27708 | 3.64516 |
| 18.00 | 6.10149 | 18.77846 | 7.99084 | 3.50406 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.50000    OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000

| $\theta_1$ | AVERAGE VALUES $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 11.56313 | 6.54220 |
| 81.00 | 172.71581 | 27.35547 | 11.51810 | 6.51223 |
| 72.00 | 83.84554 | 27.24306 | 11.47077 | 6.48071 |
| 63.00 | 53.22292 | 27.11841 | 11.41829 | 6.44578 |
| 54.00 | 37.12366 | 26.97191 | 11.35661 | 6.40471 |
| 45.00 | 26.78728 | 26.78728 | 11.27883 | 6.35296 |
| 36.00 | 19.27750 | 26.53319 | 11.17189 | 6.28173 |
| 27.00 | 13.31771 | 26.13744 | 11.00525 | 6.17078 |
| 18.00 | 8.24799 | 25.38466 | 10.68829 | 5.95976 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.60000    OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000

| $\theta_1$ | AVERAGE VALUES $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 16.08852 | 11.59285 |
| 81.00 | 243.05417 | 38.49599 | 16.03998 | 11.54623 |
| 72.00 | 118.10152 | 38.37349 | 15.98897 | 11.49720 |
| 63.00 | 75.04575 | 38.23769 | 15.93239 | 11.44286 |
| 54.00 | 52.40999 | 38.07808 | 15.86589 | 11.37897 |
| 45.00 | 37.87697 | 37.87697 | 15.78208 | 11.29346 |
| 36.00 | 27.31810 | 37.60013 | 15.66674 | 11.18766 |
| 27.00 | 18.93854 | 37.16898 | 15.48709 | 11.01509 |
| 18.00 | 11.81047 | 36.34888 | 15.14537 | 10.68683 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.70000    OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000

| $\theta_1$ | AVERAGE VALUES $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 24.59856 | 22.91747 |
| 81.00 | 375.79932 | 59.52086 | 24.54468 | 22.84224 |
| 72.00 | 182.76360 | 59.38344 | 24.48801 | 22.76311 |
| 63.00 | 116.24776 | 59.23116 | 24.42522 | 22.67542 |
| 54.00 | 81.27831 | 59.05211 | 24.35138 | 22.57230 |
| 45.00 | 58.82651 | 58.82651 | 24.25632 | 22.44240 |
| 36.00 | 42.51436 | 58.51601 | 24.13028 | 22.26360 |
| 27.00 | 29.56894 | 58.03232 | 23.93055 | 21.98511 |
| 18.00 | 18.55695 | 57.11240 | 23.55150 | 21.45537 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.80000    OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000

| $\theta_1$ | AVERAGE VALUES $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 44.51508 | 56.30098 |
| 81.00 | 687.53125 | 108.89435 | 44.44666 | 56.16556 |
| 72.00 | 334.59961 | 108.71802 | 44.37468 | 56.02315 |
| 63.00 | 212.98755 | 108.52254 | 44.29488 | 55.86530 |
| 54.00 | 149.05222 | 108.29276 | 44.20113 | 55.67972 |
| 45.00 | 108.00322 | 108.00322 | 44.08292 | 55.44535 |
| 36.00 | 78.17937 | 107.60471 | 43.92026 | 55.12401 |
| 27.00 | 54.51105 | 106.98398 | 43.66692 | 54.62270 |
| 18.00 | 34.37758 | 105.80333 | 43.18503 | 53.66916 |

TABLE 3 STRESS INTENSITY AND DISPLACEMENTS COEFFICIENTS FOR INTERNALLY
CRACKED RING SEGMENTS WITH RATIO OF OUTER TO INNER RADIUS = 1.50

### RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.10000   OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000

| $\theta_1$ | AVERAGE VALUES | | | |
| --- | --- | --- | --- | --- |
| | KB√W/P | KB√W/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
| 90.00 | | | 4.07204 | 0.63060 |
| 81.00 | 32.51706 | 5.15020 | 4.03937 | 0.62720 |
| 72.00 | 15.71590 | 5.10640 | 4.00502 | 0.62362 |
| 63.00 | 9.92661 | 5.05786 | 3.96695 | 0.61965 |
| 54.00 | 6.88300 | 5.00079 | 3.92219 | 0.61498 |
| 45.00 | 4.92383 | 4.92888 | 3.86579 | 0.60910 |
| 36.00 | 3.50913 | 4.82990 | 3.78816 | 0.60101 |
| 27.00 | 2.38241 | 4.67574 | 3.66725 | 0.58840 |

### RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.20000   OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000

| $\theta_1$ | AVERAGE VALUES | | | |
| --- | --- | --- | --- | --- |
| | KB√W/P | KB√W/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
| 90.00 | | | 5.57158 | 1.35877 |
| 81.00 | 45.29822 | 7.17453 | 5.51887 | 1.34660 |
| 72.00 | 21.85918 | 7.10249 | 5.46345 | 1.33381 |
| 63.00 | 13.78267 | 7.02262 | 5.40201 | 1.31962 |
| 54.00 | 9.53658 | 6.92873 | 5.32979 | 1.30295 |
| 45.00 | 6.81043 | 6.81043 | 5.23879 | 1.28194 |
| 36.00 | 4.82976 | 6.64760 | 5.11353 | 1.25302 |
| 27.00 | 3.25789 | 6.39398 | 4.91845 | 1.20798 |

### RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.30000   OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000

| $\theta_1$ | AVERAGE VALUES | | | |
| --- | --- | --- | --- | --- |
| | KB√W/P | KB√W/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
| 90.00 | | | 7.08236 | 2.39357 |
| 81.00 | 58.70255 | 9.29758 | 7.01704 | 2.37352 |
| 72.00 | 28.33490 | 9.20657 | 6.94836 | 2.35244 |
| 63.00 | 17.87093 | 9.10570 | 6.87222 | 2.32907 |
| 54.00 | 12.36970 | 8.98711 | 6.78273 | 2.30160 |
| 45.00 | 8.83768 | 8.83768 | 6.66995 | 2.26699 |
| 36.00 | 6.27153 | 8.63202 | 6.51473 | 2.21934 |
| 27.00 | 4.23501 | 8.31168 | 6.27297 | 2.14513 |

### RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.40000   OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000

| $\theta_1$ | AVERAGE VALUES | | | |
| --- | --- | --- | --- | --- |
| | KB√W/P | KB√W/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
| 90.00 | | | 9.00246 | 3.95934 |
| 81.00 | 76.11835 | 12.05596 | 8.93034 | 3.92034 |
| 72.00 | 36.78937 | 11.95360 | 8.85451 | 3.87934 |
| 63.00 | 23.23752 | 11.84012 | 8.77046 | 3.83388 |
| 54.00 | 16.11292 | 11.70672 | 8.67164 | 3.78044 |
| 45.00 | 11.53863 | 11.53863 | 8.54713 | 3.71310 |
| 36.00 | 8.21521 | 11.30727 | 8.37575 | 3.62042 |
| 27.00 | 5.57773 | 10.94692 | 8.10883 | 3.47606 |

### RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.50000   OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000

| $\theta_1$ | AVERAGE VALUES | | | |
| --- | --- | --- | --- | --- |
| | KB√W/P | KB√W/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
| 90.00 | | | 11.77301 | 6.69004 |
| 81.00 | 101.52071 | 16.07927 | 11.69404 | 6.63300 |
| 72.00 | 49.13556 | 15.96513 | 11.61100 | 6.57303 |
| 63.00 | 31.08450 | 15.83356 | 11.51896 | 6.50655 |
| 54.00 | 21.59511 | 15.68978 | 11.41075 | 6.42940 |
| 45.00 | 15.50230 | 15.50230 | 11.27440 | 6.32991 |
| 36.00 | 11.07560 | 15.24426 | 11.03673 | 6.19437 |
| 27.00 | 7.56255 | 14.84235 | 10.79443 | 5.98326 |

### RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.60000   OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000

| $\theta_1$ | AVERAGE VALUES | | | |
| --- | --- | --- | --- | --- |
| | KB√W/P | KB√W/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
| 90.00 | | | 16.31090 | 11.76417 |
| 81.00 | 143.43523 | 22.71790 | 16.22707 | 11.68100 |
| 72.00 | 69.53867 | 22.59447 | 16.13592 | 11.59354 |
| 63.00 | 44.07567 | 22.45766 | 16.04120 | 11.49659 |
| 54.00 | 30.63896 | 22.29683 | 15.92633 | 11.30261 |
| 45.00 | 22.09418 | 22.09418 | 15.78157 | 11.23900 |
| 36.00 | 15.84972 | 21.81525 | 15.58234 | 11.04134 |
| 27.00 | 10.89407 | 21.38080 | 15.27202 | 10.73347 |

### RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.70000   OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000

| $\theta_1$ | AVERAGE VALUES | | | |
| --- | --- | --- | --- | --- |
| | KB√W/P | KB√W/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
| 90.00 | | | 24.85602 | 23.15607 |
| 81.00 | 222.81348 | 35.29015 | 24.76500 | 23.02518 |
| 72.00 | 108.19237 | 35.15381 | 24.66933 | 22.58750 |
| 63.00 | 68.69662 | 35.00266 | 24.56325 | 22.73438 |
| 54.00 | 47.93248 | 34.82497 | 24.43857 | 22.55550 |
| 45.00 | 34.60109 | 34.60109 | 24.28145 | 22.32944 |
| 36.00 | 24.91527 | 34.29294 | 24.06522 | 22.01833 |
| 27.00 | 17.22855 | 33.81293 | 23.72838 | 21.53374 |

### RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.80000   OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000

| $\theta_1$ | AVERAGE VALUES | | | |
| --- | --- | --- | --- | --- |
| | KB√W/P | KB√W/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
| 90.00 | | | 45.15500 | 56.91649 |
| 81.00 | 412.46924 | 65.32869 | 45.05428 | 56.69568 |
| 72.00 | 200.53361 | 65.17516 | 44.94335 | 56.46352 |
| 63.00 | 127.57938 | 65.00493 | 44.83093 | 56.20618 |
| 54.00 | 89.19620 | 64.80481 | 44.69298 | 55.90363 |
| 45.00 | 64.55266 | 64.55266 | 44.51906 | 55.52262 |
| 36.00 | 46.64809 | 64.20563 | 44.27974 | 54.99773 |
| 27.00 | 32.43895 | 63.66504 | 43.90691 | 54.18047 |

TABLE 4 STRESS INTENSITY AND DISPLACEMENTS COEFFICIENTS FOR INTERNALLY
CRACKED RING SEGMENTS WITH RATIO OF OUTER TO INNER RADIUS = 2.00

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.10000    OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000

AVERAGE VALUES

| $\theta_1$ | KB$\sqrt{W}$/P | KB$\sqrt{W}$/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
|---|---|---|---|---|
| 90.00 | | | 4.46437 | 0.69771 |
| 81.00 | 21.51981 | 3.40841 | 4.39794 | 0.69007 |
| 72.00 | 10.32339 | 3.35427 | 4.32809 | 0.68205 |
| 63.00 | 6.46536 | 3.29427 | 4.25067 | 0.67315 |
| 54.00 | 4.43708 | 3.22373 | 4.15965 | 0.66269 |
| 45.00 | 3.13484 | 3.13484 | 4.04495 | 0.64950 |
| 36.00 | 2.18871 | 3.01250 | 3.88709 | 0.63136 |
| 31.50 | 1.79517 | 2.92946 | 3.77995 | 0.61905 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.20000    OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000

AVERAGE VALUES

| $\theta_1$ | KB$\sqrt{W}$/P | KB$\sqrt{W}$/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
|---|---|---|---|---|
| 90.00 | | | 5.96029 | 1.47476 |
| 81.00 | 29.60886 | 4.68958 | 5.86198 | 1.45449 |
| 72.00 | 14.17856 | 4.60689 | 5.75862 | 1.43319 |
| 63.00 | 8.86163 | 4.51522 | 5.64403 | 1.40957 |
| 54.00 | 6.06635 | 4.40746 | 5.50933 | 1.38181 |
| 45.00 | 4.27168 | 4.27168 | 5.33959 | 1.34682 |
| 36.00 | 2.96776 | 4.08478 | 5.10598 | 1.29867 |
| 31.50 | 2.42542 | 3.95793 | 4.94741 | 1.26599 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.30000    OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000

AVERAGE VALUES

| $\theta_1$ | KB$\sqrt{W}$/P | KB$\sqrt{W}$/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
|---|---|---|---|---|
| 90.00 | | | 7.43880 | 2.56918 |
| 81.00 | 38.14632 | 6.04179 | 7.32338 | 2.52999 |
| 72.00 | 18.28653 | 5.94166 | 7.20201 | 2.48879 |
| 63.00 | 11.44332 | 5.83066 | 7.06747 | 2.44311 |
| 54.00 | 7.84563 | 5.70019 | 6.90932 | 2.38941 |
| 45.00 | 5.53577 | 5.53577 | 6.71002 | 2.32175 |
| 36.00 | 3.85756 | 5.30947 | 6.43572 | 2.22862 |
| 31.50 | 3.15952 | 5.15587 | 6.24955 | 2.16541 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.40000    OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000

AVERAGE VALUES

| $\theta_1$ | KB$\sqrt{W}$/P | KB$\sqrt{W}$/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
|---|---|---|---|---|
| 90.00 | | | 9.31607 | 4.20203 |
| 81.00 | 49.32607 | 7.81248 | 9.19116 | 4.13972 |
| 72.00 | 23.70073 | 7.70085 | 9.05982 | 4.07420 |
| 63.00 | 14.87090 | 7.57710 | 8.91424 | 4.00158 |
| 54.00 | 10.22876 | 7.43162 | 8.74309 | 3.91620 |
| 45.00 | 7.24831 | 7.24831 | 8.52743 | 3.80862 |
| 36.00 | 5.08290 | 6.99601 | 8.23060 | 3.66055 |
| 31.50 | 4.18222 | 6.82476 | 8.02913 | 3.56005 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.50000    OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000

AVERAGE VALUES

| $\theta_1$ | KB$\sqrt{W}$/P | KB$\sqrt{W}$/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
|---|---|---|---|---|
| 90.00 | | | 12.06770 | 6.93703 |
| 81.00 | 65.94565 | 10.44477 | 11.93638 | 6.84244 |
| 72.00 | 31.77524 | 10.32442 | 11.79934 | 6.74299 |
| 63.00 | 20.00095 | 10.19101 | 11.64686 | 6.63275 |
| 54.00 | 13.81085 | 10.03417 | 11.46763 | 6.50315 |
| 45.00 | 9.83655 | 9.83655 | 11.24177 | 6.33985 |
| 36.00 | 6.94904 | 9.56454 | 10.93090 | 6.11503 |
| 31.50 | 5.74802 | 9.37992 | 10.71990 | 5.96252 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.60000    OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000

AVERAGE VALUES

| $\theta_1$ | KB$\sqrt{W}$/P | KB$\sqrt{W}$/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
|---|---|---|---|---|
| 90.00 | | | 16.59865 | 12.08308 |
| 81.00 | 93.54697 | 14.81639 | 16.46265 | 11.94150 |
| 72.00 | 45.20398 | 14.68768 | 16.31563 | 11.79263 |
| 63.00 | 28.54613 | 14.54500 | 16.16109 | 11.62761 |
| 54.00 | 19.78859 | 14.37727 | 15.97474 | 11.43362 |
| 45.00 | 14.16591 | 14.16591 | 15.73991 | 11.18917 |
| 36.00 | 10.08079 | 13.87501 | 15.41668 | 10.85272 |
| 31.50 | 8.38162 | 13.67756 | 15.19729 | 10.62435 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.70000    OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000

AVERAGE VALUES

| $\theta_1$ | KB$\sqrt{W}$/P | KB$\sqrt{W}$/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
|---|---|---|---|---|
| 90.00 | | | 25.17603 | 23.54680 |
| 81.00 | 146.19829 | 23.15552 | 25.03299 | 23.33025 |
| 72.00 | 70.83725 | 23.01639 | 24.85260 | 23.10257 |
| 63.00 | 44.86960 | 22.86220 | 24.71590 | 22.85016 |
| 54.00 | 31.21761 | 22.63091 | 24.51990 | 22.55347 |
| 45.00 | 22.45250 | 22.45250 | 24.27295 | 22.17960 |
| 36.00 | 16.08426 | 22.13303 | 23.93306 | 21.66501 |
| 31.50 | 13.43548 | 21.92470 | 23.70235 | 21.31572 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.80000    OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000

AVERAGE VALUES

| $\theta_1$ | KB$\sqrt{W}$/P | KB$\sqrt{W}$/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
|---|---|---|---|---|
| 90.00 | | | 45.74254 | 57.43601 |
| 81.00 | 273.45142 | 43.31049 | 45.58997 | 57.12810 |
| 72.00 | 132.82697 | 43.15310 | 45.42953 | 56.75179 |
| 63.00 | 84.37096 | 42.98914 | 45.25171 | 56.33469 |
| 54.00 | 58.89618 | 42.78056 | 45.04271 | 55.84430 |
| 45.00 | 42.54030 | 42.54030 | 44.77930 | 55.22641 |
| 36.00 | 30.65712 | 42.19591 | 44.41675 | 54.37509 |
| 31.50 | 25.71442 | 41.96210 | 44.17064 | 53.79865 |

TABLE 5 STRESS INTENSITY AND DISPLACEMENTS COEFFICIENTS FOR INTERNALLY
CRACKED RING SEGMENTS WITH RATIO OF OUTER TO INNER RADIUS = 2.50

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.10000      OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000

| $\theta_1$ | AVERAGE VALUES | | | |
| | KB$\sqrt{W}$/P | KB$\sqrt{W}$/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
| --- | --- | --- | --- | --- |
| 90.00 | | | 4.79007 | 0.75610 |
| 81.00 | 18.02173 | 2.85436 | 4.69082 | 0.74420 |
| 72.00 | 8.58937 | 2.79085 | 4.58645 | 0.73168 |
| 63.00 | 5.33920 | 2.72046 | 4.47076 | 0.71780 |
| 54.00 | 3.63048 | 2.63770 | 4.33476 | 0.70149 |
| 45.00 | 2.53342 | 2.53342 | 4.16339 | 0.68094 |
| 36.00 | 1.73636 | 2.38989 | 3.92751 | 0.65266 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.20000      OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000

| $\theta_1$ | AVERAGE VALUES | | | |
| | KB$\sqrt{W}$/P | KB$\sqrt{W}$/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
| --- | --- | --- | --- | --- |
| 90.00 | | | 6.28751 | 1.58251 |
| 81.00 | 24.59546 | 3.89554 | 6.14924 | 1.55238 |
| 72.00 | 11.70578 | 3.80344 | 6.00385 | 1.52072 |
| 63.00 | 7.26429 | 3.70134 | 5.84269 | 1.48561 |
| 54.00 | 4.92926 | 3.58132 | 5.65323 | 1.44434 |
| 45.00 | 3.43008 | 3.43008 | 5.41449 | 1.39233 |
| 36.00 | 2.34086 | 3.22192 | 5.08591 | 1.32076 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.30000      OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000

| $\theta_1$ | AVERAGE VALUES | | | |
| | KB$\sqrt{W}$/P | KB$\sqrt{W}$/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
| --- | --- | --- | --- | --- |
| 90.00 | | | 7.72773 | 2.71834 |
| 81.00 | 31.48398 | 4.98658 | 7.57263 | 2.66429 |
| 72.00 | 15.01661 | 4.87919 | 7.40956 | 2.60745 |
| 63.00 | 9.34233 | 4.76015 | 7.22878 | 2.54445 |
| 54.00 | 6.35918 | 4.62021 | 7.01627 | 2.47039 |
| 45.00 | 4.44388 | 4.44388 | 6.74850 | 2.37706 |
| 36.00 | 3.05234 | 4.20118 | 6.37993 | 2.24861 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.40000      OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000

| $\theta_1$ | AVERAGE VALUES | | | |
| | KB$\sqrt{W}$/P | KB$\sqrt{W}$/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
| --- | --- | --- | --- | --- |
| 90.00 | | | 9.55208 | 4.41380 |
| 81.00 | 40.52454 | 6.41846 | 9.39058 | 4.32815 |
| 72.00 | 19.39676 | 6.30240 | 9.22077 | 4.23809 |
| 63.00 | 12.11665 | 6.17374 | 9.03254 | 4.13827 |
| 54.00 | 8.28926 | 6.02250 | 8.81126 | 4.02091 |
| 45.00 | 5.83191 | 5.83191 | 8.53243 | 3.87504 |
| 36.00 | 4.04655 | 5.56960 | 8.14865 | 3.66951 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.50000      OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000

| $\theta_1$ | AVERAGE VALUES | | | |
| | KB$\sqrt{W}$/P | KB$\sqrt{W}$/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
| --- | --- | --- | --- | --- |
| 90.00 | | | 12.26336 | 7.18902 |
| 81.00 | 54.12383 | 8.57238 | 12.09934 | 7.06174 |
| 72.00 | 26.00696 | 8.45018 | 11.92686 | 6.92791 |
| 63.00 | 16.31856 | 8.31473 | 11.73568 | 6.77957 |
| 54.00 | 11.22507 | 8.15549 | 11.51093 | 6.60517 |
| 45.00 | 7.95484 | 7.95484 | 11.22772 | 6.38543 |
| 36.00 | 5.57888 | 7.67867 | 10.83792 | 6.08297 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.60000      OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000

| $\theta_1$ | AVERAGE VALUES | | | |
| | KB$\sqrt{W}$/P | KB$\sqrt{W}$/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
| --- | --- | --- | --- | --- |
| 90.00 | | | 16.77895 | 12.37014 |
| 81.00 | 76.91956 | 12.18287 | 16.60921 | 12.18474 |
| 72.00 | 37.09203 | 12.05194 | 16.43073 | 11.93981 |
| 63.00 | 23.36841 | 11.90682 | 16.23285 | 11.77372 |
| 54.00 | 16.15349 | 11.73621 | 16.00026 | 11.51969 |
| 45.00 | 11.52124 | 11.52124 | 15.70721 | 11.19960 |
| 36.00 | 8.15569 | 11.22535 | 15.30382 | 10.75904 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.70000      OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000

| $\theta_1$ | AVERAGE VALUES | | | |
| | KB$\sqrt{W}$/P | KB$\sqrt{W}$/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
| --- | --- | --- | --- | --- |
| 90.00 | | | 25.36823 | 23.87317 |
| 81.00 | 120.63765 | 19.10712 | 25.19066 | 23.59549 |
| 72.00 | 58.36980 | 18.96547 | 25.00394 | 23.30356 |
| 63.00 | 36.91376 | 18.80649 | 24.79697 | 22.97992 |
| 54.00 | 25.63564 | 18.62395 | 24.55365 | 22.59946 |
| 45.00 | 18.39139 | 18.39139 | 24.24706 | 22.12006 |
| 36.00 | 13.12959 | 18.07132 | 23.82506 | 21.46004 |

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.80000      OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000

| $\theta_1$ | AVERAGE VALUES | | | |
| | KB$\sqrt{W}$/P | KB$\sqrt{W}$/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
| --- | --- | --- | --- | --- |
| 90.00 | | | 45.83170 | 57.85904 |
| 81.00 | 225.74921 | 35.75513 | 45.63515 | 57.41141 |
| 72.00 | 109.54468 | 35.59319 | 45.42850 | 56.94072 |
| 63.00 | 69.50330 | 35.41370 | 45.19916 | 56.41901 |
| 54.00 | 48.45232 | 35.20267 | 44.93004 | 55.80562 |
| 45.00 | 34.93677 | 34.93677 | 44.59064 | 55.03273 |
| 36.00 | 25.11713 | 34.57079 | 44.12357 | 53.96904 |

TABLE 6 -STRESS INTENSITY AND DISPLACEMENT COEFFICIENTS FOR EXTERNALLY
CRACKED RING SEGMENTS WITH RATIO OF OUTER TO INNER RADIUS = 1.10000

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.10000      OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000

AVERAGE VALUES

| $\theta_1$ | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB{\sim}W^{**}1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 3.40499 | 0.52013 |
| 81.00 | 112.14354 | 17.76175 | 3.39938 | 0.51952 |
| 72.00 | 54.57024 | 17.73093 | 3.39348 | 0.51888 |
| 63.00 | 34.73186 | 17.69675 | 3.38694 | 0.51818 |
| 54.00 | 24.30222 | 17.65659 | 3.37926 | 0.51734 |
| 45.00 | 17.60599 | 17.60599 | 3.36957 | 0.51630 |
| 36.00 | 12.74092 | 17.53635 | 3.35624 | 0.51486 |
| 27.00 | 8.87995 | 17.42786 | 3.33548 | 0.51261 |
| 18.00 | 5.59562 | 17.22153 | 3.29599 | 0.50835 |
| 11.46 | 3.42155 | 16.87819 | 3.23028 | 0.50124 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.20000      OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000

AVERAGE VALUES

| $\theta_1$ | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB{\sim}W^{**}1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 4.88435 | 1.17330 |
| 81.00 | 160.02080 | 25.34473 | 4.87399 | 1.17107 |
| 72.00 | 77.82883 | 25.28809 | 4.86310 | 1.16873 |
| 63.00 | 49.50742 | 25.22527 | 4.85102 | 1.16613 |
| 54.00 | 34.61803 | 25.15146 | 4.83682 | 1.16308 |
| 45.00 | 25.05843 | 25.05843 | 4.81893 | 1.15924 |
| 36.00 | 18.11301 | 24.93042 | 4.79431 | 1.15395 |
| 27.00 | 12.60109 | 24.73099 | 4.75597 | 1.14570 |
| 18.00 | 7.91235 | 24.35170 | 4.68302 | 1.13003 |
| 11.46 | 4.80864 | 23.72060 | 4.56166 | 1.10395 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.30000      OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000

AVERAGE VALUES

| $\theta_1$ | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB{\sim}W^{**}1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 6.41543 | 2.13729 |
| 81.00 | 209.16878 | 33.12897 | 6.40174 | 2.13371 |
| 72.00 | 101.73145 | 33.05449 | 6.38735 | 2.12994 |
| 63.00 | 64.71107 | 32.97191 | 6.37139 | 2.12577 |
| 54.00 | 45.24840 | 32.87485 | 6.35264 | 2.12086 |
| 45.00 | 32.75258 | 32.75258 | 6.32900 | 2.11468 |
| 36.00 | 23.67383 | 32.53423 | 6.29647 | 2.10617 |
| 27.00 | 16.46839 | 32.32204 | 6.24581 | 2.09292 |
| 18.00 | 10.34003 | 31.82332 | 6.14944 | 2.06771 |
| 11.46 | 6.28301 | 30.99355 | 5.98910 | 2.02578 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.40000      OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000

AVERAGE VALUES

| $\theta_1$ | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB{\sim}W^{**}1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 8.34409 | 3.66353 |
| 81.00 | 270.77344 | 42.88620 | 8.32743 | 3.65632 |
| 72.00 | 131.71265 | 42.79596 | 8.30990 | 3.64873 |
| 63.00 | 83.79558 | 42.69594 | 8.29048 | 3.64033 |
| 54.00 | 58.60410 | 42.57837 | 8.26765 | 3.63045 |
| 45.00 | 42.43021 | 42.43021 | 8.23388 | 3.61800 |
| 36.00 | 30.67917 | 42.22623 | 8.19928 | 3.60086 |
| 27.00 | 21.35352 | 41.90862 | 8.13761 | 3.57417 |
| 18.00 | 13.42064 | 41.30443 | 8.02029 | 3.52339 |
| 11.46 | 8.16946 | 40.29921 | 7.82510 | 3.43892 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.50000      OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000

AVERAGE VALUES

| $\theta_1$ | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB{\sim}W^{**}1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 11.11270 | 6.27110 |
| 81.00 | 358.95313 | 56.85248 | 11.09318 | 6.25929 |
| 72.00 | 174.65050 | 56.74730 | 11.07265 | 6.24667 |
| 63.00 | 111.14409 | 56.63068 | 11.04990 | 6.23311 |
| 54.00 | 77.75631 | 56.49364 | 11.02316 | 6.21693 |
| 45.00 | 56.32088 | 56.32088 | 10.98045 | 6.19655 |
| 36.00 | 40.74677 | 56.08313 | 10.94386 | 6.16849 |
| 27.00 | 28.38707 | 55.71283 | 10.87081 | 6.12479 |
| 18.00 | 17.87334 | 55.00847 | 10.73337 | 6.04166 |
| 11.46 | 10.91375 | 53.83658 | 10.50471 | 5.90335 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.60000      OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000

AVERAGE VALUES

| $\theta_1$ | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB{\sim}W^{**}1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 15.78628 | 11.10609 |
| 81.00 | 507.64087 | 80.40224 | 15.76516 | 11.08528 |
| 72.00 | 247.10435 | 80.28896 | 15.74294 | 11.06339 |
| 63.00 | 157.32967 | 80.16341 | 15.71832 | 11.03913 |
| 54.00 | 110.13234 | 80.01534 | 15.68939 | 11.01062 |
| 45.00 | 79.82985 | 79.82985 | 15.65292 | 10.97469 |
| 36.00 | 57.81300 | 79.57337 | 15.60273 | 10.92523 |
| 27.00 | 40.34174 | 79.17516 | 15.52455 | 10.84819 |
| 18.00 | 25.47913 | 78.41675 | 15.37584 | 10.70167 |
| 11.46 | 15.64085 | 77.15494 | 15.12844 | 10.45788 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.70000      OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000

AVERAGE VALUES

| $\theta_1$ | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB{\sim}W^{**}1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 24.07573 | 22.41327 |
| 81.00 | 770.64966 | 122.05872 | 24.05095 | 22.37859 |
| 72.00 | 375.25122 | 121.92653 | 24.02492 | 22.34209 |
| 63.00 | 239.00693 | 121.78003 | 23.99602 | 22.30164 |
| 54.00 | 167.37883 | 121.60785 | 23.96213 | 22.25409 |
| 45.00 | 121.39081 | 121.39081 | 23.91933 | 22.19420 |
| 36.00 | 87.97858 | 121.09212 | 23.86049 | 22.11172 |
| 27.00 | 61.46245 | 120.62691 | 23.76880 | 21.98331 |
| 18.00 | 38.90648 | 119.74196 | 23.59447 | 21.73900 |
| 11.46 | 23.97559 | 118.26964 | 23.30437 | 21.33257 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.80000      OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000

AVERAGE VALUES

| $\theta_1$ | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB{\sim}W^{**}1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 43.52396 | 55.19655 |
| 81.00 | 1386.59009 | 219.61391 | 43.48787 | 55.13080 |
| 72.00 | 675.31226 | 219.42223 | 43.44991 | 55.06168 |
| 63.00 | 430.22290 | 219.20975 | 43.40781 | 54.98505 |
| 54.00 | 301.37207 | 218.96007 | 43.35840 | 54.89502 |
| 45.00 | 218.64539 | 218.64539 | 43.28607 | 54.78154 |
| 36.00 | 158.54047 | 218.21222 | 43.21033 | 54.62531 |
| 27.00 | 110.84087 | 217.53760 | 43.07671 | 54.33196 |
| 18.00 | 70.26526 | 216.25432 | 42.82262 | 53.91919 |
| 11.46 | 43.40619 | 214.11931 | 42.39983 | 53.14922 |

TABLE 7   STRESS INTENSITY AND DISPLACEMENTS COEFFICIENTS FOR EXTERNALLY
          CRACKED RING SEGMENTS WITH RATIO OF OUTER TO INNER RADIUS = 1.25

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.10000      OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000

AVERAGE VALUES

| $\theta_1$ | KB√W/P | KB√W/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
|---|---|---|---|---|
| 90.00 | | | 3.23810 | 0.49616 |
| 81.00 | 45.29805 | 7.17449 | 3.22449 | 0.49453 |
| 72.00 | 21.98282 | 7.14264 | 3.21018 | 0.49280 |
| 63.00 | 13.94895 | 7.10734 | 3.19431 | 0.49089 |
| 54.00 | 9.72530 | 7.06584 | 3.17566 | 0.48865 |
| 45.00 | 7.01355 | 7.01355 | 3.15216 | 0.48582 |
| 36.00 | 5.04335 | 6.94157 | 3.11981 | 0.48193 |
| 27.00 | 3.47979 | 6.82947 | 3.06942 | 0.47587 |
| 18.00 | 2.14974 | 6.61622 | 2.97358 | 0.46433 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.20000      OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000

AVERAGE VALUES

| $\theta_1$ | KB√W/P | KB√W/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
|---|---|---|---|---|
| 90.00 | | | 4.71146 | 1.15838 |
| 81.00 | 65.11728 | 10.31355 | 4.68797 | 1.15435 |
| 72.00 | 31.57458 | 10.25921 | 4.66328 | 1.15013 |
| 63.00 | 20.01662 | 10.19898 | 4.63590 | 1.14544 |
| 54.00 | 13.94024 | 10.12818 | 4.60371 | 1.13994 |
| 45.00 | 10.03896 | 10.03896 | 4.56316 | 1.13300 |
| 36.00 | 7.20450 | 9.91615 | 4.50734 | 1.12345 |
| 27.00 | 4.95507 | 9.72489 | 4.42040 | 1.10857 |
| 18.00 | 3.04159 | 9.36106 | 4.25503 | 1.08028 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.30000      OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000

AVERAGE VALUES

| $\theta_1$ | KB√W/P | KB√W/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
|---|---|---|---|---|
| 90.00 | | | 6.22256 | 2.11108 |
| 81.00 | 85.01143 | 13.46446 | 6.19056 | 2.10084 |
| 72.00 | 41.21410 | 13.39127 | 6.15691 | 2.09007 |
| 63.00 | 26.12259 | 13.31013 | 6.11960 | 2.07814 |
| 54.00 | 18.18854 | 13.21476 | 6.07575 | 2.06411 |
| 45.00 | 13.09457 | 13.09457 | 6.02049 | 2.04643 |
| 36.00 | 9.39358 | 12.92915 | 5.94444 | 2.02209 |
| 27.00 | 6.45645 | 12.67150 | 5.82598 | 1.98419 |
| 18.00 | 3.95798 | 12.18142 | 5.60065 | 1.91210 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.40000      OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000

AVERAGE VALUES

| $\theta_1$ | KB√W/P | KB√W/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
|---|---|---|---|---|
| 90.00 | | | 8.13824 | 3.60996 |
| 81.00 | 109.93201 | 17.41147 | 8.09836 | 3.59242 |
| 72.00 | 53.30965 | 17.32132 | 8.05644 | 3.57397 |
| 63.00 | 33.79892 | 17.22141 | 8.00996 | 3.55352 |
| 54.00 | 23.54155 | 17.10396 | 7.95534 | 3.52848 |
| 45.00 | 16.95595 | 16.95595 | 7.88649 | 3.49919 |
| 36.00 | 12.17121 | 16.75223 | 7.79174 | 3.45749 |
| 27.00 | 8.37402 | 16.43491 | 7.64416 | 3.39256 |
| 18.00 | 5.14393 | 15.83140 | 7.36344 | 3.26903 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.50000      OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000

AVERAGE VALUES

| $\theta_1$ | KB√W/P | KB√W/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
|---|---|---|---|---|
| 90.00 | | | 10.90292 | 6.15979 |
| 81.00 | 145.65404 | 23.06926 | 10.85613 | 6.13100 |
| 72.00 | 70.67824 | 22.96474 | 10.83694 | 6.10072 |
| 63.00 | 44.84340 | 22.84885 | 10.75241 | 6.06717 |
| 54.00 | 31.26122 | 22.71262 | 10.65331 | 6.02772 |
| 45.00 | 22.54097 | 22.54097 | 10.60753 | 5.97832 |
| 36.00 | 16.20531 | 22.30469 | 10.49635 | 5.90960 |
| 27.00 | 11.17733 | 21.93674 | 10.32319 | 5.80305 |
| 18.00 | 6.90026 | 21.23679 | 9.99380 | 5.60036 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.60000      OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000

AVERAGE VALUES

| $\theta_1$ | KB√W/P | KB√W/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
|---|---|---|---|---|
| 90.00 | | | 15.38266 | 11.07014 |
| 81.00 | 203.24219 | 32.19031 | 15.32873 | 11.02222 |
| 72.00 | 98.70525 | 32.07123 | 15.27203 | 10.97183 |
| 63.00 | 62.68436 | 31.93924 | 15.20918 | 10.91597 |
| 54.00 | 43.74706 | 31.78409 | 15.13530 | 10.85032 |
| 45.00 | 31.53858 | 31.53858 | 15.04220 | 10.76757 |
| 36.00 | 22.75493 | 31.31949 | 14.91406 | 10.65369 |
| 27.00 | 15.74652 | 30.90033 | 14.71447 | 10.47631 |
| 18.00 | 9.78110 | 30.10309 | 14.33482 | 10.13892 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.70000      OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000

AVERAGE VALUES

| $\theta_1$ | KB√W/P | KB√W/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
|---|---|---|---|---|
| 90.00 | | | 23.68050 | 22.12500 |
| 81.00 | 309.33740 | 48.9941 | 23.61160 | 22.04150 |
| 72.00 | 150.32420 | 48.8433 | 23.53890 | 21.95360 |
| 63.00 | 95.53210 | 48.67600 | 23.45930 | 21.85630 |
| 54.00 | 66.72620 | 48.47940 | 23.36360 | 21.74190 |
| 45.00 | 48.23170 | 48.23170 | 23.24420 | 21.59760 |
| 36.00 | 34.7946 | 47.89070 | 23.07990 | 21.39920 |
| 27.00 | 24.1309 | 47.35960 | 22.82390 | 21.09000 |
| 18.00 | 15.05950 | 46.34940 | 22.33710 | 20.50200 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.80000      OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000

AVERAGE VALUES

| $\theta_1$ | KB√W/P | KB√W/PTAN$\theta_1$ | KB~W**1.5/M | EBVW/6M |
|---|---|---|---|---|
| 90.00 | | | 42.50757 | 54.32529 |
| 81.00 | 548.99927 | 86.95279 | 42.41597 | 54.16327 |
| 72.00 | 267.00552 | 86.75536 | 42.31969 | 53.99297 |
| 63.00 | 169.83762 | 86.53653 | 42.21291 | 53.80414 |
| 54.00 | 118.75370 | 86.27933 | 42.08745 | 53.58220 |
| 45.00 | 85.95517 | 85.95517 | 41.92934 | 53.30251 |
| 36.00 | 62.12559 | 85.50399 | 41.71169 | 52.91756 |
| 27.00 | 43.21490 | 84.81412 | 41.37273 | 52.31793 |
| 18.00 | 27.17827 | 83.49231 | 40.72794 | 51.17746 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.10000     OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000

| $\theta_1$ | AVERAGE VALUES | | | |
|---|---|---|---|---|
| | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
| 90.00 | | | 3.01690 | 0.46132 |
| 81.00 | 23.13881 | 3.66482 | 2.99169 | 0.45644 |
| 72.00 | 11.17926 | 3.63236 | 2.96519 | 0.45131 |
| 63.00 | 7.05828 | 3.59637 | 2.93581 | 0.44563 |
| 54.00 | 4.89175 | 3.55406 | 2.90128 | 0.43896 |
| 45.00 | 3.50076 | 3.50076 | 2.85776 | 0.43054 |
| 36.00 | 2.49014 | 3.42738 | 2.79787 | 0.41896 |
| 27.00 | 1.68811 | 3.31310 | 2.70457 | 0.40092 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.20000     OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000

| $\theta_1$ | AVERAGE VALUES | | | |
|---|---|---|---|---|
| | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
| 90.00 | | | 4.45059 | 1.08192 |
| 81.00 | 33.41852 | 5.29297 | 4.41081 | 1.07439 |
| 72.00 | 16.13560 | 5.24278 | 4.36899 | 1.06646 |
| 63.00 | 10.18036 | 5.18714 | 4.32262 | 1.05768 |
| 54.00 | 7.04948 | 5.12175 | 4.26812 | 1.04736 |
| 45.00 | 5.03934 | 5.03934 | 4.19944 | 1.03435 |
| 36.00 | 3.57888 | 4.92591 | 4.10492 | 1.01644 |
| 27.00 | 2.41985 | 4.74923 | 3.95769 | 0.98855 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.30000     OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000

| $\theta_1$ | AVERAGE VALUES | | | |
|---|---|---|---|---|
| | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
| 90.00 | | | 5.93413 | 2.02575 |
| 81.00 | 43.60915 | 6.90700 | 5.87830 | 2.01147 |
| 72.00 | 21.04529 | 6.83802 | 5.81960 | 1.99644 |
| 63.00 | 13.27033 | 6.76157 | 5.75452 | 1.97979 |
| 54.00 | 9.18278 | 6.67168 | 5.67803 | 1.96022 |
| 45.00 | 6.55842 | 6.55842 | 5.58164 | 1.93556 |
| 36.00 | 4.65171 | 6.40253 | 5.44397 | 1.90160 |
| 27.00 | 3.13854 | 6.15973 | 5.24232 | 1.84873 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.40000     OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000

| $\theta_1$ | AVERAGE VALUES | | | |
|---|---|---|---|---|
| | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
| 90.00 | | | 7.83115 | 3.47914 |
| 81.00 | 56.34752 | 8.92456 | 7.76049 | 3.45029 |
| 72.00 | 27.20398 | 8.83911 | 7.68618 | 3.41995 |
| 63.00 | 17.16185 | 8.74440 | 7.60382 | 3.38632 |
| 54.00 | 11.88239 | 8.63306 | 7.50701 | 3.34679 |
| 45.00 | 8.49276 | 8.49276 | 7.38501 | 3.29697 |
| 36.00 | 6.03005 | 8.29966 | 7.21709 | 3.22841 |
| 27.00 | 4.07564 | 7.99889 | 6.95556 | 3.12162 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.50000     OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000

| $\theta_1$ | AVERAGE VALUES | | | |
|---|---|---|---|---|
| | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
| 90.00 | | | 10.57264 | 5.97580 |
| 81.00 | 74.48868 | 11.79782 | 10.48696 | 5.92360 |
| 72.00 | 35.99805 | 11.69647 | 10.39686 | 5.86873 |
| 63.00 | 22.73508 | 11.58412 | 10.29700 | 5.80790 |
| 54.00 | 15.76239 | 11.45204 | 10.17959 | 5.73639 |
| 45.00 | 11.28562 | 11.28562 | 10.03166 | 5.64628 |
| 36.00 | 8.03305 | 11.05655 | 9.82804 | 5.52227 |
| 27.00 | 5.45180 | 10.69977 | 9.51090 | 5.32910 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.60000     OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000

| $\theta_1$ | AVERAGE VALUES | | | |
|---|---|---|---|---|
| | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
| 90.00 | | | 15.02785 | 10.76825 |
| 81.00 | 103.67545 | 16.42052 | 14.92777 | 10.67371 |
| 72.00 | 50.18102 | 16.30478 | 14.82254 | 10.57430 |
| 63.00 | 31.74811 | 16.17644 | 14.70589 | 10.46410 |
| 54.00 | 22.05736 | 16.02562 | 14.56877 | 10.33456 |
| 45.00 | 15.83556 | 15.83556 | 14.39598 | 10.17132 |
| 36.00 | 11.31514 | 15.57395 | 14.15813 | 9.94665 |
| 27.00 | 7.72770 | 15.16647 | 13.78770 | 9.59671 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.70000     OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000

| $\theta_1$ | AVERAGE VALUES | | | |
|---|---|---|---|---|
| | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
| 90.00 | | | 23.28165 | 21.71143 |
| 81.00 | 157.13904 | 24.88831 | 23.15192 | 21.55649 |
| 72.00 | 76.14708 | 24.74164 | 23.01546 | 21.39359 |
| 63.00 | 48.23920 | 24.57909 | 22.86426 | 21.21297 |
| 54.00 | 33.56717 | 24.38799 | 22.68651 | 21.00069 |
| 45.00 | 24.14719 | 24.14719 | 22.46251 | 20.73314 |
| 36.00 | 17.30315 | 23.81572 | 22.15417 | 20.36496 |
| 27.00 | 11.87171 | 23.29950 | 21.67397 | 19.79146 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.80000     OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000

| $\theta_1$ | AVERAGE VALUES | | | |
|---|---|---|---|---|
| | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
| 90.00 | | | 41.73752 | 53.31734 |
| 81.00 | 275.45264 | 43.62735 | 41.54987 | 53.00175 |
| 72.00 | 133.63370 | 43.42014 | 41.35254 | 52.66997 |
| 63.00 | 84.76616 | 43.19048 | 41.13379 | 52.30214 |
| 54.00 | 59.07497 | 42.92049 | 40.87665 | 51.86980 |
| 45.00 | 42.58028 | 42.58025 | 40.55266 | 51.32500 |
| 36.00 | 30.59615 | 42.11200 | 40.10666 | 50.57503 |
| 27.00 | 21.08549 | 41.38266 | 39.41205 | 49.40706 |

TABLE 9 STRESS INTENSITY AND DISPLACEMENTS COEFFICIENTS FOR EXTERNALLY
CRACKED RING SEGMENTS WITH RATIO OF OUTER TO INNER RADIUS = 2.00

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.10000      OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000

AVERAGE VALUES

| $\theta_1$ | KB√W/P | KB√W/PTAN$\theta_1$ | KB-W**1.5/M | EBVW/6M |
|---|---|---|---|---|
| 90.00 | | | 2.70978 | 0.41853 |
| 81.00 | 12.24214 | 1.93896 | 2.67443 | 0.41362 |
| 72.00 | 5.88457 | 1.91201 | 2.63725 | 0.40845 |
| 63.00 | 3.69390 | 1.88213 | 2.59605 | 0.40272 |
| 54.00 | 2.54220 | 1.84701 | 2.54761 | 0.39599 |
| 45.00 | 1.80276 | 1.80276 | 2.48657 | 0.38750 |
| 36.00 | 1.26553 | 1.74186 | 2.40256 | 0.37582 |
| 31.50 | 1.04208 | 1.70051 | 2.34554 | 0.36789 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.20000      OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000

AVERAGE VALUES

| $\theta_1$ | KB√W/P | KB√W/PTAN$\theta_1$ | KB-W**1.5/M | EBVW/6M |
|---|---|---|---|---|
| 90.00 | | | 4.05786 | 1.02187 |
| 81.00 | 17.66382 | 2.79767 | 3.99667 | 1.00769 |
| 72.00 | 8.47175 | 2.75264 | 3.93234 | 0.99279 |
| 63.00 | 5.30438 | 2.70271 | 3.86102 | 0.97626 |
| 54.00 | 3.63919 | 2.64402 | 3.77718 | 0.95683 |
| 45.00 | 2.57008 | 2.57008 | 3.67154 | 0.93235 |
| 36.00 | 1.79332 | 2.46829 | 3.52613 | 0.89865 |
| 31.50 | 1.47024 | 2.39923 | 3.42744 | 0.87578 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.30000      OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000

AVERAGE VALUES

| $\theta_1$ | KB√W/P | KB√W/PTAN$\theta_1$ | KB-W**1.5/M | EBVW/6M |
|---|---|---|---|---|
| 90.00 | | | 5.50141 | 1.90659 |
| 81.00 | 23.06711 | 3.65347 | 5.41255 | 1.87819 |
| 72.00 | 11.05014 | 3.59040 | 5.31912 | 1.84833 |
| 63.00 | 6.90937 | 3.52049 | 5.21555 | 1.81523 |
| 54.00 | 4.73244 | 3.43832 | 5.09381 | 1.77632 |
| 45.00 | 3.33476 | 3.33476 | 4.94039 | 1.72729 |
| 36.00 | 2.31729 | 3.19223 | 4.72923 | 1.65981 |
| 31.50 | 1.89691 | 3.09569 | 4.53590 | 1.61400 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.40000      OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000

AVERAGE VALUES

| $\theta_1$ | KB√W/P | KB√W/PTAN$\theta_1$ | KB-W**1.5/M | EBVW/6M |
|---|---|---|---|---|
| 90.00 | | | 7.36677 | 3.30554 |
| 81.00 | 29.74901 | 4.71177 | 7.24889 | 3.25656 |
| 72.00 | 14.25342 | 4.63121 | 7.12494 | 3.20507 |
| 63.00 | 8.91399 | 4.54190 | 6.98755 | 3.14800 |
| 54.00 | 6.10689 | 4.43692 | 6.82603 | 3.08090 |
| 45.00 | 4.30463 | 4.30463 | 6.62250 | 2.99635 |
| 36.00 | 2.99520 | 4.12254 | 6.34238 | 2.87998 |
| 31.50 | 2.45056 | 3.99895 | 6.15224 | 2.80100 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.50000      OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000

AVERAGE VALUES

| $\theta_1$ | KB√W/P | KB√W/PTAN$\theta_1$ | KB-W**1.5/M | EBVW/6M |
|---|---|---|---|---|
| 90.00 | | | 10.05509 | 5.74891 |
| 81.00 | 39.09540 | 6.19209 | 9.90736 | 5.65547 |
| 72.00 | 18.75853 | 6.09502 | 9.75203 | 5.55721 |
| 63.00 | 11.75095 | 5.98740 | 9.57985 | 5.44829 |
| 54.00 | 8.06684 | 5.86090 | 9.37744 | 5.32026 |
| 45.00 | 5.70149 | 5.70149 | 9.12239 | 5.15893 |
| 36.00 | 3.98297 | 5.48209 | 8.77135 | 4.93687 |
| 31.50 | 3.26817 | 5.33317 | 8.53307 | 4.78615 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.60000      OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000

AVERAGE VALUES

| $\theta_1$ | KB√W/P | KB√W/PTAN$3_1$ | KB-W**1.5/M | EBVW/6M |
|---|---|---|---|---|
| 90.00 | | | 14.40894 | 10.49678 |
| 81.00 | 53.90140 | 8.53713 | 14.22856 | 10.35985 |
| 72.00 | 25.92435 | 8.42334 | 14.03890 | 10.21586 |
| 63.00 | 16.28415 | 8.29719 | 13.82866 | 10.05626 |
| 54.00 | 11.21600 | 8.14890 | 13.58151 | 9.86863 |
| 45.00 | 7.96205 | 7.96205 | 13.27008 | 9.63221 |
| 36.00 | 5.59791 | 7.70486 | 12.84144 | 9.30680 |
| 31.50 | 4.61457 | 7.53030 | 12.55049 | 9.08594 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.70000      OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000

AVERAGE VALUES

| $\theta_1$ | KB√W/P | KB√W/PTAN$\theta_1$ | KB-W**1.5/M | EBVW/6M |
|---|---|---|---|---|
| 90.00 | | | 22.59163 | 21.23659 |
| 81.00 | 81.17862 | 12.85741 | 22.36069 | 20.96230 |
| 72.00 | 39.14133 | 12.71779 | 22.11789 | 20.67386 |
| 63.00 | 24.65630 | 12.56302 | 21.84871 | 20.35413 |
| 54.00 | 17.04108 | 12.38109 | 21.53232 | 19.97826 |
| 45.00 | 12.15184 | 12.15184 | 21.13361 | 19.50467 |
| 36.00 | 8.59957 | 11.83629 | 20.58481 | 18.85280 |
| 31.50 | 7.12204 | 11.62212 | 20.21236 | 18.41034 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.80000      OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000

AVERAGE VALUES

| $\theta_1$ | KB√W/P | KB√W/PTAN$\theta_1$ | KB-W**1.5/M | EBVW/6M |
|---|---|---|---|---|
| 90.00 | | | 41.42943 | 52.68433 |
| 81.00 | 142.67728 | 22.59778 | 41.08693 | 52.10941 |
| 72.00 | 68.93938 | 22.39972 | 40.72681 | 51.50490 |
| 63.00 | 43.53107 | 22.18015 | 40.32758 | 50.83481 |
| 54.00 | 30.17313 | 21.92206 | 39.85831 | 50.04706 |
| 45.00 | 21.59685 | 21.59685 | 39.26700 | 49.05449 |
| 36.00 | 15.36581 | 21.14919 | 38.45308 | 47.68828 |
| 31.50 | 12.77407 | 20.84537 | 37.90067 | 46.76099 |

TABLE 10   STRESS INTENSITY AND DISPLACEMENTS COEFFICIENTS FOR EXTERNALLY
           CRACKED RING SEGMENTS WITH RATIO OF OUTER TO INNER RADIUS = 2.50

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.10000      OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000

AVERAGE VALUES

| $\theta_1$ | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 2.48465 | 0.38703 |
| 81.00 | 8.61043 | 1.36375 | 2.44182 | 0.38129 |
| 72.00 | 4.11979 | 1.33860 | 2.39678 | 0.37526 |
| 63.00 | 2.57242 | 1.31072 | 2.34685 | 0.36857 |
| 54.00 | 1.75893 | 1.27794 | 2.28816 | 0.36071 |
| 45.00 | 1.23663 | 1.23663 | 2.21420 | 0.35081 |
| 36.00 | 0.85716 | 1.17978 | 2.11241 | 0.33717 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.20000      OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000

AVERAGE VALUES

| $\theta_1$ | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 3.77303 | 0.96481 |
| 81.00 | 12.45324 | 1.97239 | 3.69708 | 0.94750 |
| 72.00 | 5.93929 | 1.92979 | 3.61723 | 0.92931 |
| 63.00 | 3.69475 | 1.88256 | 3.52871 | 0.90913 |
| 54.00 | 2.51472 | 1.82705 | 3.42465 | 0.88541 |
| 45.00 | 1.75710 | 1.75710 | 3.29353 | 0.85553 |
| 36.00 | 1.20665 | 1.66081 | 3.11305 | 0.81440 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.30000      OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000

AVERAGE VALUES

| $\theta_1$ | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 5.19167 | 1.81565 |
| 81.00 | 16.30704 | 2.58278 | 5.07921 | 1.78107 |
| 72.00 | 7.76394 | 2.52265 | 4.96097 | 1.74472 |
| 63.00 | 4.82018 | 2.45600 | 4.82990 | 1.70442 |
| 54.00 | 3.27256 | 2.37765 | 4.67582 | 1.65704 |
| 45.00 | 2.27893 | 2.27893 | 4.48167 | 1.59735 |
| 36.00 | 1.55701 | 2.14304 | 4.21443 | 1.51518 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.40000      OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000

AVERAGE VALUES

| $\theta_1$ | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 7.03633 | 3.19583 |
| 81.00 | 21.01578 | 3.32857 | 6.88432 | 3.13106 |
| 72.00 | 10.00643 | 3.25128 | 6.72447 | 3.06295 |
| 63.00 | 6.21287 | 3.16561 | 6.54729 | 2.98745 |
| 54.00 | 4.21847 | 3.06490 | 6.33899 | 2.89869 |
| 45.00 | 2.93800 | 2.93800 | 6.07652 | 2.78685 |
| 36.00 | 2.00768 | 2.76333 | 5.71527 | 2.63292 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.50000      OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000

AVERAGE VALUES

| $\theta_1$ | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 9.68712 | 5.62766 |
| 81.00 | 27.47765 | 4.35203 | 9.49188 | 5.51062 |
| 72.00 | 13.10449 | 4.25790 | 9.28660 | 5.38755 |
| 63.00 | 8.15183 | 4.15356 | 9.05902 | 5.25113 |
| 54.00 | 5.54806 | 4.03090 | 8.79151 | 5.09077 |
| 45.00 | 3.87635 | 3.87635 | 8.45442 | 4.88869 |
| 36.00 | 2.66178 | 3.66362 | 7.99045 | 4.61055 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.60000      OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000

AVERAGE VALUES

| $\theta_1$ | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 13.95096 | 10.34590 |
| 81.00 | 37.51105 | 5.94116 | 13.70510 | 11.04417 |
| 72.00 | 17.94011 | 5.82910 | 13.44660 | 9.93203 |
| 63.00 | 11.19646 | 5.70488 | 13.16004 | 9.69689 |
| 54.00 | 7.65110 | 5.55884 | 12.82318 | 9.42047 |
| 45.00 | 5.37484 | 5.37484 | 12.39870 | 9.07215 |
| 36.00 | 3.72104 | 5.12156 | 11.81446 | 8.59273 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.70000      OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000

AVERAGE VALUES

| $\theta_1$ | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 21.95084 | 21.01714 |
| 81.00 | 55.78148 | 8.83490 | 21.62766 | 20.64525 |
| 72.00 | 26.76378 | 8.69608 | 21.28783 | 20.25423 |
| 63.00 | 16.76500 | 8.54220 | 20.91112 | 19.82074 |
| 54.00 | 11.50836 | 8.36131 | 20.46831 | 19.31119 |
| 45.00 | 8.13337 | 8.13337 | 19.91031 | 18.66910 |
| 36.00 | 5.68130 | 7.81964 | 19.14229 | 17.78534 |

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.80000      OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000

AVERAGE VALUES

| $\theta_1$ | $KB\sqrt{W}/P$ | $KB\sqrt{W}/PTAN\theta_1$ | $KB-W**1.5/M$ | $EBVW/6M$ |
|---|---|---|---|---|
| 90.00 | | | 41.35901 | 52.51659 |
| 81.00 | 99.00940 | 15.68151 | 40.89049 | 51.71660 |
| 72.00 | 47.68129 | 15.49259 | 40.39786 | 50.87549 |
| 63.00 | 29.99486 | 15.28316 | 39.85175 | 49.94304 |
| 54.00 | 20.69658 | 15.03697 | 39.20978 | 48.84691 |
| 45.00 | 14.72674 | 14.72674 | 38.40088 | 47.46576 |
| 36.00 | 10.38938 | 14.29975 | 37.28745 | 45.56473 |

TABLE 11. – Values of the dimensionless stress intensity coefficient for radially cracked ring segments in three-point bending with R1 = 45°.

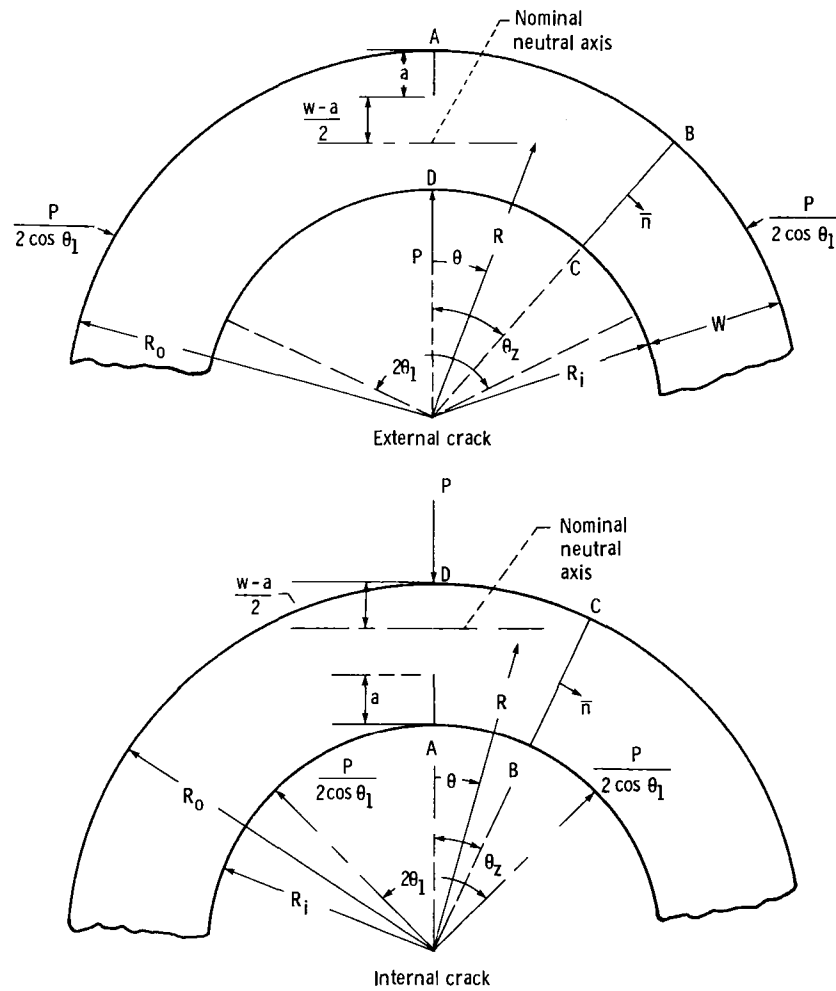| a/W | Internal Crack | | Straight[a] Bar | External Crack | |
|---|---|---|---|---|---|
| | | | $R_o/R_i$ | | |
| | 2.5 | 1.1 | 1.0 | 1.1 | 2.5 |
| | Dimensionless Curvature | | | | |
| | $(R_o - R_i)/R_i$ | | | $(R_o - R_i)/(-R_o)$ | |
| | 1.5 | 0.1 | 0 | -0.091 | -0.6 |
| | $KB(W - a)^{3/2}/M(a/W)^{1/2}$ | | | | |
| 0.0 | | | 11.932 | | |
| 0.1 | 11.241 | 10.025 | 9.147 | 9.097 | 5.978 |
| 0.2 | 8.663 | 8.134 | 7.519 | 7.710 | 5.270 |
| 0.3 | 7.216 | 7.059 | 6.506 | 6.767 | 4.792 |
| 0.4 | 6.270 | 6.254 | 5.825 | 6.054 | 4.465 |
| 0.5 | 5.614 | 5.639 | 5.325 | 5.495 | 4.227 |
| 0.6 | 5.130 | 5.111 | 4.927 | 5.112 | 4.049 |
| 0.7 | 4.762 | 4.749 | 4.596 | 4.698 | 3.910 |
| 0.8 | 4.459 | 4.390 | 4.321 | 4.330 | 3.840 |
| 0.9 | | | 4.110 | | |
| 1.0 | | | 3.980 | | |

[a]Reference 3

Figure 1. - Ring segment (ARC-BEND) specimen subjected to three point radial loading.

| 1. Report No. NASA TM-83059 | 2. Government Accession No. | 3. Recipient's Catalog No. |
|---|---|---|
| 4. Title and Subtitle STRESS INTENISTY AND DISPLACEMENT COEFFICIENTS FOR RADIALLY CRACKED RING SEGMENTS SUBJECT TO THREE-POINT BENDING | | 5. Report Date March 1983 |
| | | 6. Performing Organization Code 505-33-32 |
| 7. Author(s) Bernard Gross and John E. Srawley | | 8. Performing Organization Report No. E-1524 |
| | | 10. Work Unit No. |
| 9. Performing Organization Name and Address National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio 44135 | | 11. Contract or Grant No. |
| | | 13. Type of Report and Period Covered Technical Memorandum |
| 12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D. C. 20546 | | 14. Sponsoring Agency Code |

15. Supplementary Notes

16. Abstract

The boundary collocation method was used to generate Mode I stress intensity and crack mouth displacement coefficients for internally and externally radially cracked ring segments (arc bend specimens) subjected to three point radial loading. Numerical results were obtained for ring segment outer-to-inner radius ratios ($R_o/R_i$) ranging from 1.10 to 2.50 and crack length-to-width ratios (a/W) ranging from 0.1 to 0.8. Stress intensity and crack mouth displacement coefficients were found to depend on the ratios $R_o/R_i$ and a/W as well as the included angle between the directions of the reaction forces.

| 17. Key Words (Suggested by Author(s)) Stress intensity coefficients; Cracks; Ring segments; Fracture toughness; Displacement coefficient | 18. Distribution Statement Unclassified – unlimited STAR Category 39 | | |
|---|---|---|---|
| 19. Security Classif. (of this report) Unclassified | 20. Security Classif. (of this page) Unclassified | 21. No. of Pages | 22. Price* |

**End of Document**